OXYGEN

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1.0 SCOPE

This data sheet address the hazards of liquid oxygen storage in large tanks or portable cylinders or large high pressure gas systems. Protection for systems handling gaseous oxygen in portable cylinders is covered in Data Sheet 7-50, *Compressed Gases in Cylinders.*

1.1 Changes

January 2012. Terminology related to ignitable liquids has been revised to provide increased clarity and consistency with regard to FM Global's loss prevention recommendations for ignitable liquid hazards.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Safeguards for Bulk Oxygen Storage

(For safeguards for portable cylinders of oxygen gas, see Data Sheet 7-50, *Compressed Gases in Cylinders.*)

2.1.1 Construction and Location

2.1.1.1 Locate bulk oxygen storage, including fixed or portable high-pressure bulk units and/or liquid-oxygen equipment, out of doors or in a detached noncombustible structure used solely for this purpose and separated as follows:

a) 75 ft (23 m) from:

Aboveground ignitable-liquid tanks of 1,000 gal (3.8 m^3) or greater capacity.

Aboveground tanks of liquefied flammable gases of over 1,000 gal (3.8 m^3) aggregate water capacity.

Low-pressure flammable-gas storage holders of 5,000 ft^3 (140 m^3) or greater capacity.

Unsprinklered combustible buildings.

Combustible yard storage.

Wood exterior walls.

b) 25 ft (7.6 m) from:

Aboveground ignitable-liquid tanks of less than 1,000 gal (3.8 m^3) capacity.

Aboveground tanks of liquefied flammable gases of 1,000 gal (3.8 m^3) or less aggregate water capacity.

Filling or vent connections to underground ignitable liquid tanks.

Low-pressure flammable-gas storage holders of less than 5,000 ft^3 (140 m^3) capacity.

Sprinklered buildings or buildings with both construction and occupancy noncombustible.

High-pressure bulk flammable-gas storage.

Ignitable-liquid unloading stations.

c) 5 ft (1.5 m) from:

Noncombustible construction having blank walls 10 ft (3 m) above and 10 ft (3 m) on each side of the equipment.

2.1.1.2 Regulators and other control equipment may be located indoors in a noncombustible building detached or cut off from main buildings or combustible storage. Cutoffs should have at least a 1 hour fire resistance rating.

2.1.1.3 Outdoor oxygen-storage equipment should preferably be located on a base of crushed stone or concrete. Keep the ground area within 15 ft (4.5 m) of the equipment free of high weeds and grass by frequent mowing or the application of a herbicide.

2.2 Safeguards for Liquid-oxygen Cylinders

2.2.1 Construction and Location

2.2.1.1 General safeguards for gaseous-oxygen cylinders are applicable to liquid-oxygen. (See Data Sheet 7-50, *Compressed Gases in Cylinders.*)

2.2.1.2 Locate cylinders and manifolds out of doors in detached buildings or in cut-off rooms of noncombustible construction. Where floor or pad drainage is needed, use wall scuppers or exterior doorways and pitch the pad to the outer edge. Do not use floor drains, trenches, or other drainage arrangement involving essentially enclosed, below-grade, or floor-level drainage-system elements. Ramp, curb, or pitch floors at interior doorways of cutoff rooms to prevent passage of liquids into or out of the room.

2.2.1.3 Limit quantities in cut-off rooms to eight cylinders or less. Locate larger quantities out of doors or in detached structures as outlined in the previous section on bulk storage.

2.2.2 Occupancy

2.2.2.1 Enclosed structures should be well ventilated. Positive mechanical ventilation of at least 0.25 cfm/ft^2 (0.08 m^3/min/m^2) of floor area or natural ventilation of 1 ft^2 (0.1 m^2) each of free inlet and outlet openings per 500 ft^2 (46.4 m^2) of floor area is recommended.

2.2.2.2 Install and handle liquid-oxygen cylinders in accordance with the manufacturer's recommendations.

2.2.2.3 Use equipment such as manifolds and cylinder leads specifically approved for service with these cylinders. When standard gas cylinders are used for standby, manifold equipment should be a high pressure type arranged and connected to the distribution system in accordance with the manufacturer's instructions.

2.2.2.4 Handle cylinders in an upright position only.

2.3 Safeguards for Piping Systems

2.3.1 Equipment and Processes

2.3.1.1 Use extra-heavy steel or nonferrous pipe and fittings if the oxygen pressure is over 150 psi (10 b) (1 MPa). For lower pressures, standard-weight pipe and fittings are satisfactory. Cast-iron fittings should not be used.

In medical oxygen gas systems, Type K or L (ASTM B-88) copper tubing may be used. Brazed fittings should be used for ¾-inch (19-mm) and larger tubing. Flared-type tubing fittings may be used in smaller sizes where the fitting is visible in the room.

2.3.1.2 Provide a relief valve in the piping system downstream of the main regulator. The start-to-discharge setting of the valve should be no higher than 125 % of the normal working pressure of the piping system. Pipe the discharge of the valve to outdoors.

2.3.1.3 Use only approved valves, separators, and station-outlet regulators. Make all connections for station outlets from the top of the branch supply line. Provide traps at low points in the piping to permit removal of condensed water.

2.3.1.4 Use welded joints whenever possible. If threaded joints are necessary, they should be carefully made up, using litharge and glycerin or proprietary materials compounded for oxygen service. Compounds containing oils should not be used. Gaskets should be entirely of noncombustible materials.

2.3.1.5 Overhead piping should be rigidly supported well above floor level and located where not exposed to excessive heat, vibration, or physical damage.

2.3.1.6 Protect piping against corrosion.

2.3.1.7 Do not install oxygen piping in the same trench or duct with ignitable-liquid piping.

2.3.1.8 Before piping is installed, hammer all fittings and pipe lengths to dislodge dirt and loose scale and then blow them out by compressed air or steam. Wash with a hot solution of sodium carbonate or trisodium phosphate to remove all grease and oil.

2.3.1.9 Pressure-test new piping at 1.5 times the working pressure.

2.3.1.10 Inspect piping at regularly scheduled intervals, and repair any leaks immediately.

3.0 SUPPORT FOR RECOMMENDATIONS

Oxygen is a colorless, odorless gas about 1.1 times as heavy as air. It constitutes about 21 % by volume of the earth's atmosphere. It is used in large amounts for oxyacetylene cutting and welding, chemical processes, steel-plant furnaces, and other applications.

Oxygen itself is neither combustible nor explosive. However, the intensity of any ordinary fire or explosion increases as the amount of oxygen in the surrounding air increases. Some materials, such as greases and oils, which produce intense fires with air, burn in an atmosphere of oxygen with explosive violence. Explosions have occurred in oxygenpressure gages when they were placed in service after being tested on common oil-filled gage testers. Oxygen at atmospheric pressure in a closed system can combine explosively with motor-lubricating oil at temperatures as low as 340°F (170°C).

Metals such as iron, which are noncombustible in air, will burn if raised to a high temperature in an oxygen atmosphere. The ignition temperatures of materials are lowered as the pressure of the oxygen atmosphere is increased.

4.0 REFERENCES

4.1 FM Global

Data Sheet 7-35, *Air Separation Processes.*
Data Sheet 7-50, *Compressed Gases in Cylinders.*

4.2 NFPA Standards

NFPA 50, *Bulk Oxygen Systems at Consumer Sites.*
NFPA 51, *Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting and Allied Processes.*
NFPA 55, *Compressed and Liquified Gases in Portable Cylinders.*
NFPA 99, *Health Care Facilities.*
NFPA 99B, *Hypobaric Facilities*

APPENDIX A GLOSSARY OF TERMS

Ignitable Liquid: Any liquid or liquid mixture that is capable of fueling a fire, including flammable liquids, combustible liquids, inflammable liquids, or any other reference to a liquid that will burn. An ignitable liquid must have a fire point.

APPENDIX B DOCUMENT REVISION HISTORY

January 2012. Terminology related to ignitable liquids has been revised to provide increased clarity and consistency with regard to FM Global's loss prevention recommendations for ignitable liquid hazards.

January 2000. This revision of the document has been reorganized to provide a consistent format and information on air liquefaction processes, previously relocated to Data Sheet 7-35, *Air Separation Processes,* has been deleted.

February 1975. Document was updated from information in the *Handbook of Industrial Loss Prevention*.

April 1994. Information on air liquefaction process relocated to Data Sheet 7-35, *Air Separation Processes.*

APPENDIX C SUPPLEMENTARY INFORMATION

C.1 General Information

The principal hazard of oxygen storage is exposure by other combustibles. If overheated by an exposure fire, oxygen tanks or cylinders may rupture. An intense fire involving the containers and associated equipment can occur in the oxygen-rich atmosphere near any breaks or leaks.

C.1.1 Bulk Storage of Liquid Oxygen.

Where large quantities of oxygen are used, liquid-oxygen storage equipment is frequently installed. The equipment usually is owned and maintained by the oxygen supplier. The volume-expansion ratio from saturated liquid at one atmosphere to gas at atmospheric pressure is about 1:862.

Liquid-oxygen equipment consists of one or more specially designed and well-insulated storage containers, a hot-water or steam-heated vaporizer, pressure regulators, relief valves, and flow controls (Fig. 1). Liquid-storage containers are constructed of stainless steel or other metal with suitable properties for low-temperature service in accordance with American Society of Mechanical Engineers (ASME) codes. A gastight carbon steel jacket encloses the container, and the space between is filled with insulation. A high vacuum is usually maintained in the space.

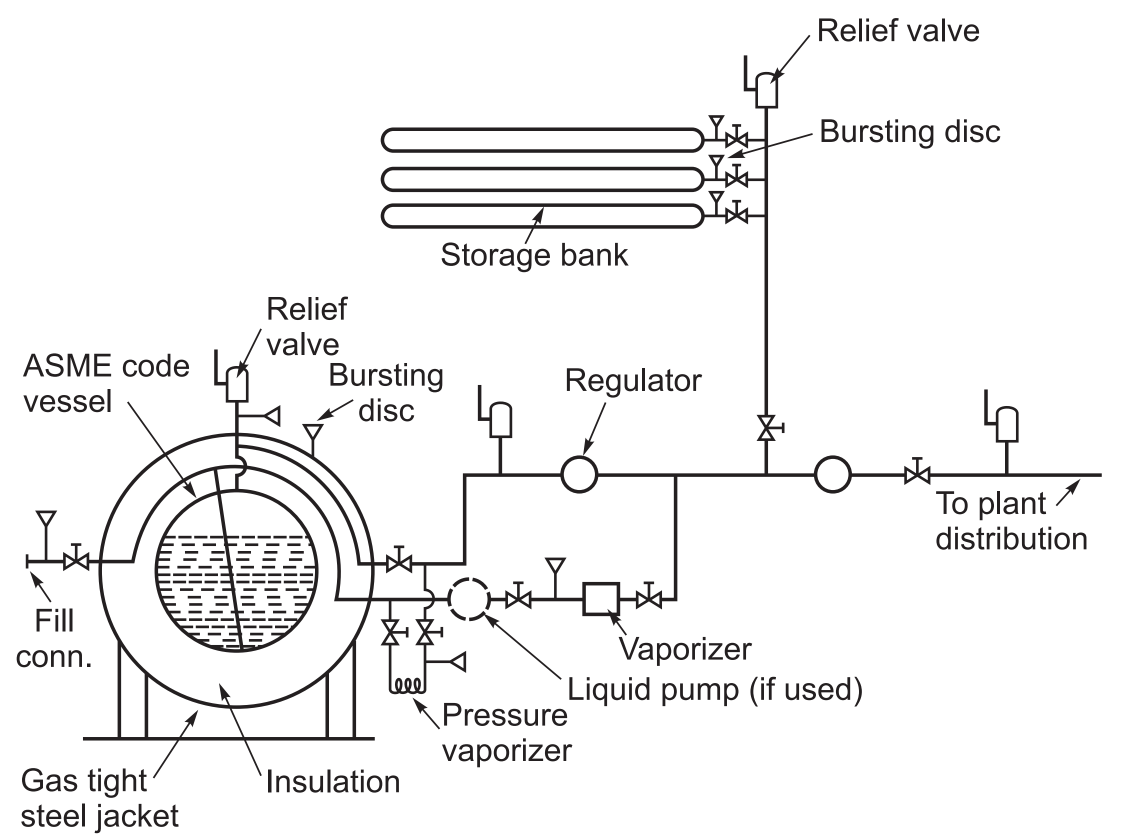


Fig. 1. Liquid-oxygen storage system.

Liquid-oxygen storage containers are usually located out of doors on steel supports or are housed in a noncombustible building, with the auxiliary equipment located either below the container or in a separate noncombustible building. The system is filled from similar containers mounted on trucks or railroad cars.

C.1.2 Bulk Storage of Gaseous Oxygen Gas

High-pressure [2,200 psi (150 b)(15 MP)] bulk storage usually is provided by storage receivers or banks of various types and sizes of fixed or portable cylinders (Fig. 2). Fixed cylinders may be installed horizontally or vertically and may be in a sheet metal enclosure or outdoors. They are filled by a compressor supplied with gaseous oxygen from a low-pressure gasholder, fixed oxygen converter, or a transport liquid-oxygen unit.

Portable systems consist of a number of cylinders mounted in a steel cradle or cabinet or on a trailer or semitrailer in either horizontal or vertical positions. Usually provision is made for several units so that empty units can be replaced without interruption of the gas supply. A regulator may be provided for each cylinder

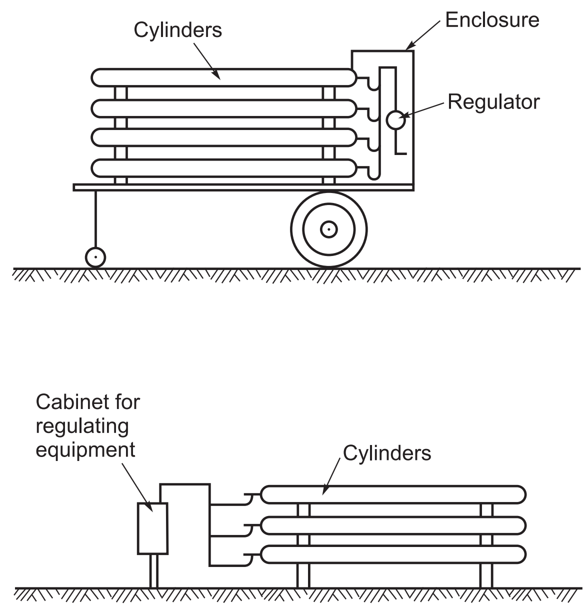


Fig. 2. High-pressure oxygen-gas storage. Typical portable installation, above; typical fixed installation, below.

bank, or all the cylinder banks may be connected to a single regulator. The piping is so arranged that changeover from one bank of cylinders to another may be readily accomplished either automatically or manually.

C.1.3 Liquid Oxygen Cylinders

Liquid-oxygen cylinders with integral provision for withdrawal of the oxygen as a gas are intended to fill the quantity-demand gap between conventional gas-cylinder systems and large bulk-liquid systems. Usually, no more than four cylinders are used in a single system.

The cylinders are combination storage vessels and vaporizers. They are jacketed, insulated containers, quite similar to the arrangement of bulk liquid-oxygen code containers. The oxygen is at low pressure as in bulk systems.

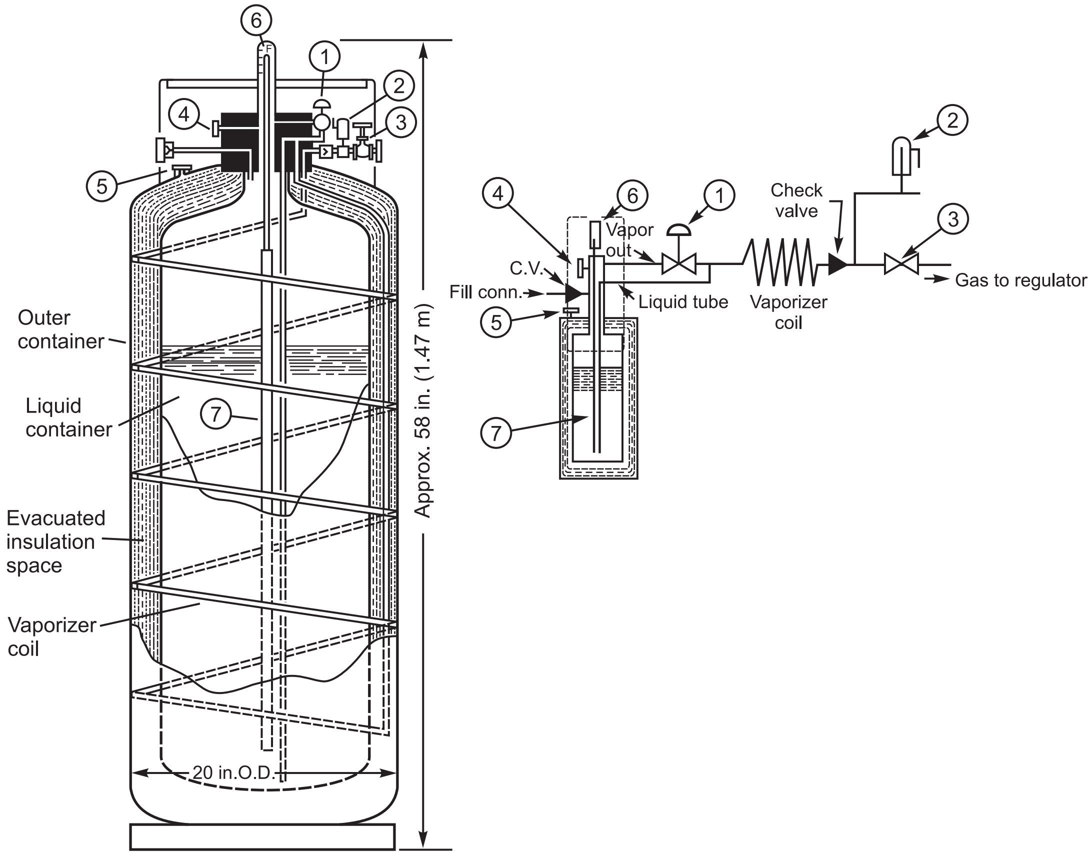
As compared with high-pressure gas cylinders, liquid-oxygen cylinders require different types of equipment, installation, and method of handling.

C.1.3.1 Description

Cylinders are constructed in accordance with U. S. Department of Transportation (D.O.T.) regulations (Fig. 3). They have a capacity of 248 lb (112 kg) or about 3.5 ft^3 (100 dm^3) of liquid oxygen, which is equivalent to about 3,000 ft^3 (85 m^3) of gaseous oxygen at normal room temperature and room pressure. One cylinder has the capacity of about 12 standard (245 ft^3)(7 m^3) gas-oxygen cylinders.

Liquid vaporization is continuous in spite of very efficient insulation and, if gas is not withdrawn, the internal cylinder pressure will rise until the relief valve operates. In an upright cylinder with insulating vacuum intact this will normally occur in three to six days, depending upon the amount of liquid in the cylinder. A full cylinder takes a longer time. Under these conditions between 2 and 3 standard cubic feet per hour (57 to 85 dm^3/hr) of gaseous oxygen will be vented. Complete loss of vacuum could increase the discharge to about 50 standard cubic feet per hour (1.4 m^3/hr).

Placement of cylinders in a horizontal position increases the vaporization rate because liquid is then in contact with the uninsulated inner container neck. This reduces the hold time for full cylinders to as little as 4 hr. It also increases the relief-valve discharge rate to about 300 standard cubic feet per hour (8.5 m^3/hr) until the liquid level drops below the neck of the inner container, usually in about 5 hr.



1. Back-pressure valve. Open whenever pressure in liquid container is 75 psi (5.2 b) (520 kPa) or higher. Closed when pressure is below 75 psi (5.2 b) (520 kPa).
2. Relief valve (235 psi) (1.6 MPa) (16 b).
3. Withdrawal valve.
4. Liquid-container bursting disk (360 psi) (2.5 Mpa) (25 b).
5. Vacuum-space bursting disk (18 psi) (125 kPa) (1.25 b).
6. Liquid-level gage.
7. Liquid-level gage float.

Fig. 3. Typical cylinder for liquid oxygen, nitrogen, or argon.

Maximum continuous withdrawal rate from a cylinder is 300 standard cubic feet per hour (8.5 m^3/hr) at 75 psi (5.2 b) (520 kPa). Rates up to 1,000 standard cubic feet per hour (28 m^3/hr) can be obtained for intermittent periods of about 5 min duration, interposed with 10-min recovery periods.

Cylinders can be manifolded using equipment specifically designed for service with these low-pressure liquid cylinders. Standard gas cylinders may be connected to the distribution system as a standby supply.

C.1.3.2 Hazards

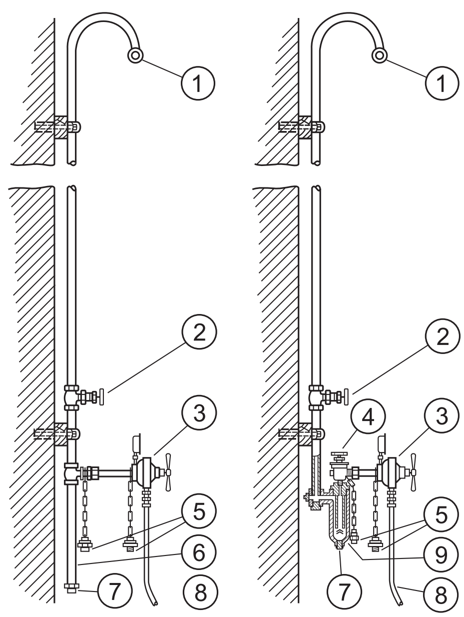
Liquid-oxygen cylinders are considered comparable to gas cylinders in overall hazard with the exception that gaseous-oxygen discharge cannot be prevented if the hold time is exceeded. In most situations, as indicated in extensive tests by the manufacturer, the hazard is that of escaping gaseous oxygen, which intensifies any ordinary fire in the area. However, the possibility of liquid-oxygen escape is present and must be considered in safeguarding an installation.

When liquid-oxygen cylinders are exposed to fire, the cylinder relief valve operates and the vaporizer coil may rupture from fire temperatures as the metal weakens and interior pressure increases. In both cases, discharge is gaseous oxygen.

When subjected to severe mechanical shock, the inner container may fail by breaking away at the neck. If this occurs, oxygen enters the vacuum space and escapes to atmosphere as a gas through the bursting disk of the outer container.

C.1.4 Piping Systems

Oxygen-distribution pipelines are supplied from a bulk storage system or cylinder manifold. Pressures vary with individual installations and are usually about 150 psi (10 b) (1 MPa). At each point of use a station outlet (Fig. 4) is provided consisting of a drop pipe, a shutoff valve, a station pressure regulator, and usually a drip leg or an oxygen-line filter.



1. Branch supply line
2. Shutoff valve (metal-tometal seat and noncombustible packing
3. Station oxygen-pressure regulator
4. Station valve (packless type)
5. Dust plug to close outlet if regulator is removed
6. Drip leg
7. Drain cap
8. Hose to torch
9. Oxygen line filter

Fig. 4. Oxygen station outlets.

Properly installed and well-maintained oxygen-distribution systems present less fire hazard than portable cylinders. Fires and explosions have occurred where flammable gases and ignitable liquids were allowed to enter the oxygen system or where combustible materials were used for valve disks and packing.